

ALD Status

{Breakdown Proof Cavities?}

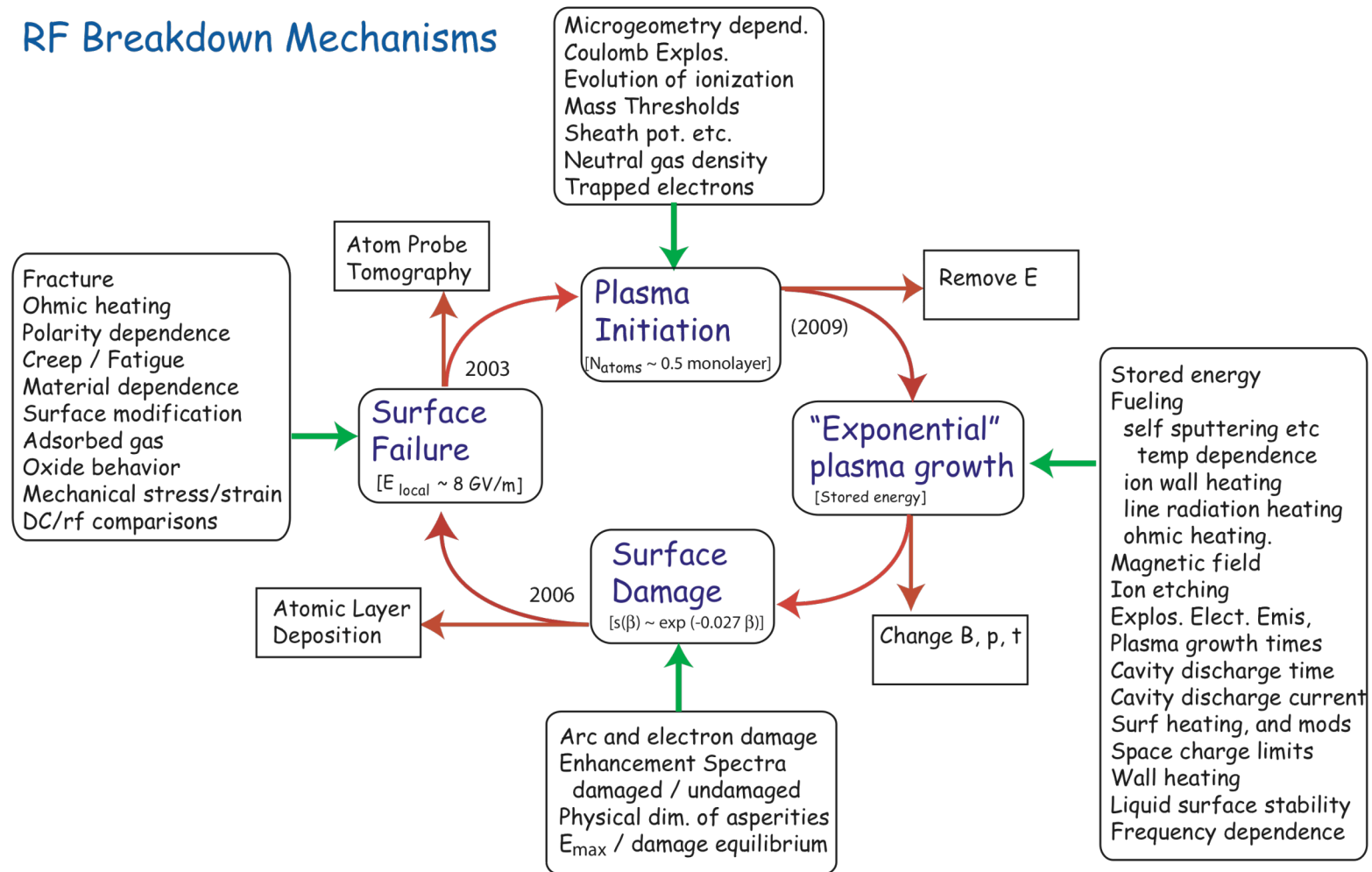
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ANL/HEP

NFMCC Fri meeting
5/29/09



We have a model of the vacuum breakdown in cavities.

RF Breakdown Mechanisms

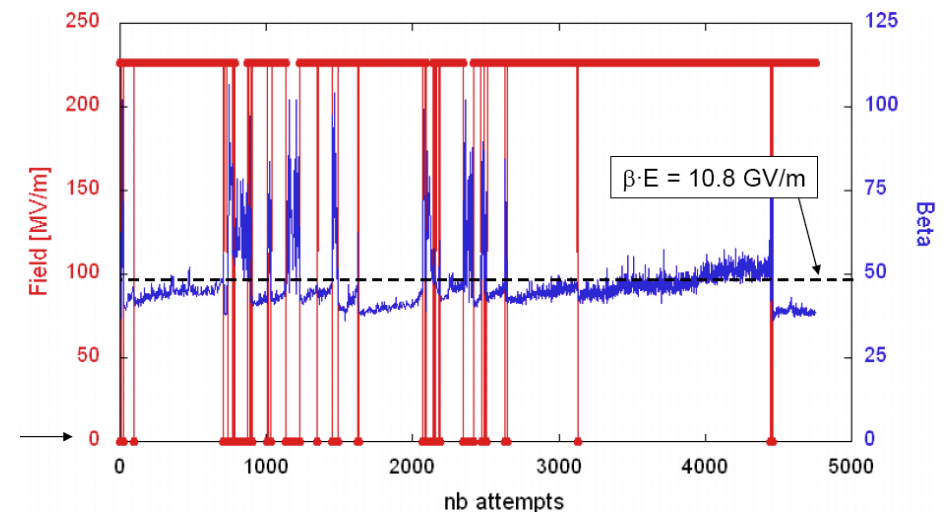


- The model shows what how the processes should fit together, but is incomplete, We are trying to understand some loose ends.
- There only seems to be one "cure".

There is some unanimity on the properties of breakdown sites.

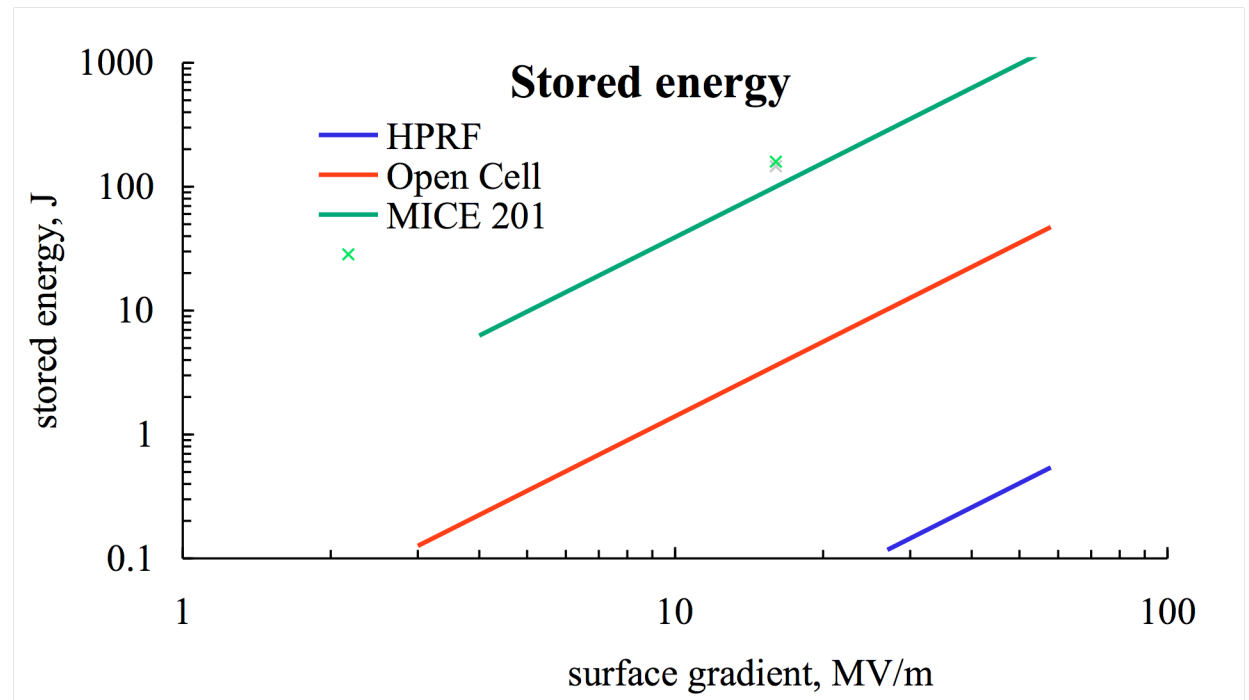
| | E_{local} V/m | radius, m | |
|--------------------------|------------------------|--------------|--------|
| Lord Kelvin, ('04) | 9.8E9 | | theory |
| Alpert et al, JVST ('64) | 8e9 | 3E-8 to 8E-8 | exp |
| KEK ('09) | 8E9 | | " |
| CERN ('09) | 10.8E9 | 2E-8 to 4E-8 | " |
| Us ('03) | 8E9 | ~5E-8 | " |

CERN data seems to show deformation of emitter tips at high fields.



Curing Field Emission and Breakdown requires elimination of sites.

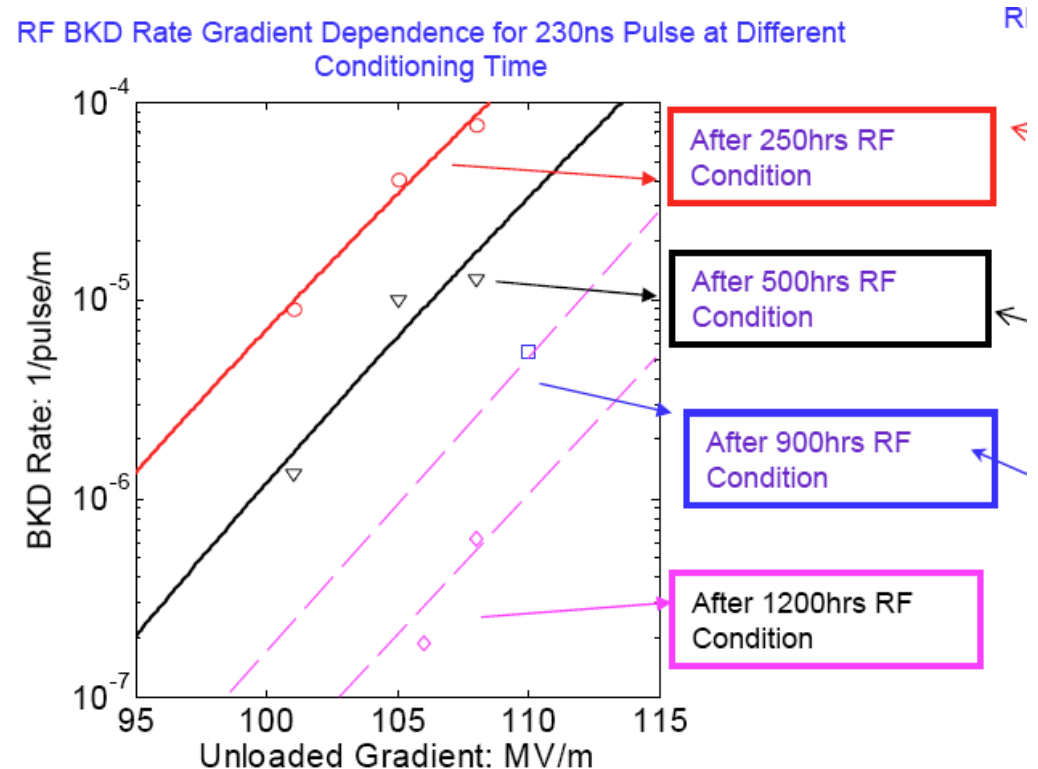
- A single breakdown event will produce emitters and more breakdown sites.
- Field emission beams are about 0.1 mA.
- Breakdown currents are of order 10 A in the pillbox.
- Stored energy problems will only get worse at 201 MHz.



Making breakdown sites duller should improve FE and BD.

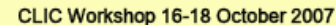
Everything goes like a very high power of the local electric field, ($E \sim 1/r$).

- Field emission goes like E^{14} .
- SLAC BD rate data $\Rightarrow r \sim E^n$, $n \sim 35$



- In Joule heating model, if $j \sim E^{14}$, $P \sim j^2$, then Joule heating power $P \sim r^{-28}$

- In Tensile stress / Fatigue model, stress $\sim E^2$, if MTBF $\sim E^{28} \Rightarrow$ red curve



Can we totally eliminate breakdown and field emission?

The technique would be:

- Condition the cavity normally up to some level, presumably making a number of field emission / breakdown sites with dimensions of ~ 50 nm.
- Apply conformal coatings with a thickness greater than 50 nm.
- Apply power.

We have made a lot of progress with ALD.

- We have coated three cavities, increasing the Q in all three, and the gradient in one.
- We have shown that strange oxides can be highly lossy for supercurrents.
- Coupon tests have shown that we can eliminate these oxides.

These, and other data will be reported by Thomas Proslie at NuFact09.

ALD can produce conformal coatings, but in-situ is best.

We have experience with superconducting structures, which seem to require High pressure water rinsing after every coating.

Our cavities are large, may eventually require recoating, are hard to move around easily, have thin Be windows and don't have drain holes, so they don't seem good candidates for high pressure water rinsing.

In situ coating avoids these problems, but have some others.

- We want to coat the high field regions of the cavity.
- We don't want to coat the rf windows / insulators.

There are solutions to these problems we are exploring (special valves, differential heating, etc.)

Summary

- It should be possible to significantly improve normal cavity technology with conformal metal coating.
- ALD technology should be able to do it.

